Comment on "Loss of Superconducting Phase Coherence in $YBa_2Cu_3O_7$ Films: Vortex-Loop Unbinding and Kosterlitz-Thouless Phenomena"

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Recently, Kötzler *et al.* [1] measured the frequency-dependent conductance for $YBa_2Cu_3O_7$ and interpreted their results as evidences that the decay of the superfluid density is caused by a 3D vortex loop proliferation mechanism and a dimensional crossover when the correlation length ξ_c along the c axis becomes comparable to the sample thickness d. In this Comment, we show that the complex conductance data presented in Ref. 1 have characteristic key features not compatible with their analysis, which are instead described by the existing phenomenology of 2D vortex fluctuation in Ref. 2 associated with a partial decoupling of CuO_2-planes. It is also argued that the suggested dimensional crossover makes the fluctuations stronger, and accordingly shifts the transition towards lower temperature. This appears to be opposite to the conclusion in Ref. 1.

In Fig. 1, G' in the complex conductance $G = G' + iG''$ from Fig. 2 in Ref. 1 is replotted as $\omega G' L_k$, with the kinetic inductance $L_k(T)$ extracted in Ref. 1. In Ref. 1, it is assumed that $\omega L_k(T)G(\omega, T) = S(\omega/\omega_0)$ with a scaling function $S = S' + iS''$ satisfying

$$S'' = 1/[1 + (\omega/\omega_0)^{-\alpha}] \tag{1}$$

and S' is obtained from the Kramer-Kronig relation [2]. Kötzler *et al.* find that their data can be characterized by $\alpha \approx 0.7$, which corresponds to the heights of the dissipation peaks equal to 0.23 (solid line in Fig. 1). However the data exceed this value by more than 40%,

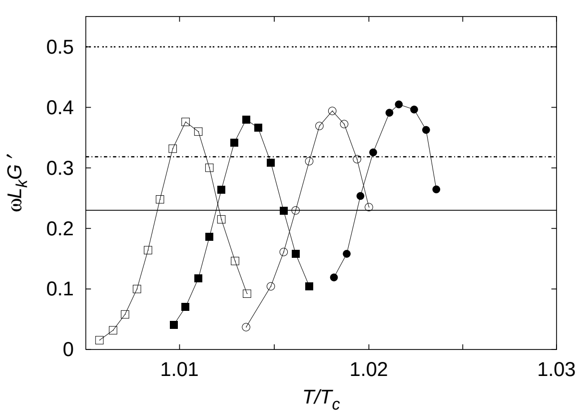

FIG. 1: Dissipative part $\omega L_k(T)G'$ vs T/T_c from Ref. 1. The curves correspond to ω = 30mHz, 3Hz, 1kHz, and 100kHz (from left to right).

and the peak height shows a systematic increase with increasing frequency, whereas Eq.(1) predicts constant peak heights: These observations imply that the scaling function (1) cannot properly describe the experimental data. The 2D vortex explanation, on the other hand, predicts that the peak heights should systematically increase with ω and should always be between $1/\pi \approx 0.32$ and 0.5 (dashed and dotted lines in the Fig. 1) [2, 3]. The lower value $1/\pi$ corresponds to the Minnhagen response form [given by $\alpha = 1$ in Eq. (1)] associated with bound vortex-antivortex pairs dominating close to the Kosterlitz-Thouless (KT) transition. The higher value 1/2 corresponds to the Drude response [given by $\alpha = 2$ in Eq. (1)], dominated by abundant free vortices well above the KT transition. Both free vortices and bound pairs are present above the KT transition with the proportion of free vortices increasing with T. This explains why the peak heights increase with T [2, 3].

Kötzler *et al.* link their proposed mechanism to an apparent sample independent onset of deviation at about $35(\mathrm{nH})^{-1}$ for the inductive data taken at 1kHz from the inferred 3D L_k^{-1}. The relevant scale where vortex type fluctuations become important may be estimated from the KT transition criteria $L_k^{-1} = 8.2 \times 10^{-2}T$ $(\mathrm{KnH})^{-1}$ giving $L_k^{-1} \approx 7(\mathrm{nH})^{-1}$ for the samples in Ref. 1. This places the KT-transition (which in principle always can be associated with a large enough sample of finite thickness) very close to the inferred 3D transition. Although $35(\mathrm{nH})^{-1}$ is larger, it is still of the same order of magnitude. This suggests that the deviation at 1kHz occurring below the inferred critical T_c (as well as below the inferred KT-transition) may indeed be caused by vortex loops. However, in such a scenario the deviation from the inferred zero frequency L_k^{-1} towards higher values is due to the *finite frequency* [2]. This deviation would then vanish in the limit of small frequency (small in the sense that the dissipation peaks in Fig. 1 cease to move to the left) implying a *frequency dependent* onset of deviations. Any change of the 3D L_k^{-1} caused by a dimensional crossover ($\xi_c \gtrsim d$) will always increase fluctuations and cause deviation in the limit of zero frequency to the *left* instead of to the *right* of the inferred 3D L_k^{-1}.

In our scenario the deviation occurs when ω/ω_0 becomes large which always happens for a T below T_c because $\omega_0 \to 0$ at T_c. The reason is that the larger ω/ω_0 the more of the larger vortex loops become ineffective in renormalizing L_k^{-1}, causing an increase from the $\omega = 0$-

value [2]. The universality found in Ref.1 implies that $\omega_0 \propto L_k^{-1}$ which is similar to what happens in the 2D XY model [4]. The point to note is that in order for the data to deviate to the right of the $\omega = 0$-data the fluctuations involved in the $\omega = 0$-data should be the ones that are made ineffective by the finite frequency. Since the $\omega = 0$-data obeys the 3D critical scaling the relevant fluctuations would have to be the usual vortex loops. Consequently the data is well explained without invoking a vortex blow out involving an additional $\xi_c/d \approx 1$ condition.

[1] J. Kötzler *et al.*, Phys. Rev. Lett. **87**, 127005 (2001).

[2] See, P. Minnhagen, Rev. Mod. Phys. **59**, 1001 (1987); B.J. Kim *et al.*, Phys. Rev. B **59**, 11 506 (1999), and references therein.

[3] Ö. Festin *et al.*, Phys. Rev. Lett. **83**, 5567 (1999).

[4] A. Jonsson and P. Minnhagen, Phys. Rev. B **55**, 9035 (1997).